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New Cereal Varieties

WHEAT and CORN in MEXICO

*May 1969
ID/FAS/USDA*

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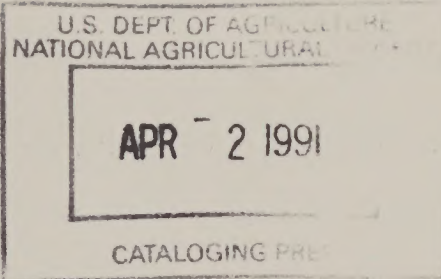
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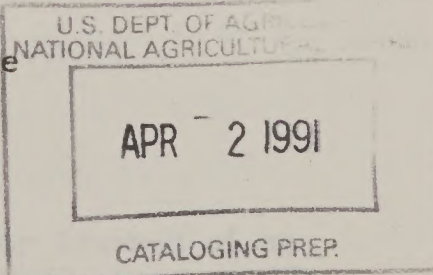
NEW VARIETIES IN MEXICO: WHEAT, CORN

AID Spring Review

by

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International Development
Foreign Agricultural Service
U. S. Department of Agriculture



PREFACE

As part of the Spring Review of new grain varieties conducted by the Agency for International Development, the author was asked to prepare a report summarizing developments with wheat and corn in Mexico.

It was recognized that the story of new varieties of grains in Mexico through the early 1960's is well told by Stakman, Bradfield and Mangelsdorf in Campaigns Against Hunger (Belknap Press of Harvard University Press, 1967, 328 pp). It was also known that recent technological advances are reviewed in the annual reports and the bi-monthly newsletter of the International Maize and Wheat Improvement Center (CIMMYT) for 1966-67 and 1967-68, and in the annual reports of the Rockefeller Foundation.

Rather than repeating this material, it was decided to supplement it by focusing on economic and social issues -- particularly those of the 1960's. * The report follows, but does not correspond precisely with a general outline suggested by AID for country crop papers.

The author is indebted to Reed Hertford of the Economic Research Service for many helpful suggestions and materials.

*

In the process of preparing the report, the author learned of an unpublished paper by Dr. Delbert Myren of the CIMMYT staff on "The Comparative Growth of Corn and Wheat in Mexico." Dr. Myren kindly loaned a manuscript copy. The final version will be published under the title of "The Rockefeller Program in Corn and Wheat in Mexico" in Subsistence Agriculture and Economic Development (ed by Clifton Wharton and published by Aldine, 1969).

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I. CROP PRODUCTION

A. Total Output

Mexico is the second largest producer of both wheat and corn in Latin America: it is second to Argentina in wheat and to Brazil in corn. In 1967, Mexico accounted for about 18% of Latin American wheat output (vs. 64% for Argentina), and about 27% of corn production (vs. 39% for Brazil).^{1/}

Estimates of exact size of the Mexican wheat and corn crops vary by source. Recent data reported by the Foreign Agricultural Service, however, indicate that in 1968 the wheat crop was about 2.2 million metric tons while corn production was about 9.2 million tons.^{2/}

Production of both wheat and corn has grown significantly over the 20-year period from 1949 to 1968. Output of both crops approximately tripled. Details -- based on FAO and Mexican Government data -- are provided in Figure 1 and Table 1.

B. Area Harvested

The area harvested for the two grains in 1968, as reported by the Foreign Agricultural Service, was approximately 750,000 hectares of wheat and 7.6 million hectares of corn. The 1968 wheat area represented an increase of about a third over 1949, while the corn area was about double. Wheat area reached a peak in 1957 while corn area reached a peak in 1966. Details, as reported by the Food and Agriculture Organization and the Mexican Government, are provided in Figure 2 and Table 2.

(Text continued on p. 6)

^{1/} Computed from data in World Agricultural Production and Trade, U.S. Department of Agriculture, November 1968, p. 22.

^{2/} Foreign Agricultural Service report MX 9019 from Mexico City, March 28, 1969.

Table 1. ESTIMATED PRODUCTION OF WHEAT AND CORN IN MEXICO

<u>Year</u>	<u>Wheat</u>	<u>Corn</u>
--metric tons--		
1949	503,000	2,871,000
1950	587,000	3,122,000
1951	590,000	3,424,000
1952	512,000	3,202,000
1953	671,000	3,720,000
1954	839,000	4,488,000
1955	850,000	4,490,000
1956	1,243,000	4,382,000
1957	1,377,000	4,500,000
1958	1,337,000	5,277,000
1959	1,264,000	5,563,000
1960	1,190,000	5,386,000
1961	1,402,000	6,246,000 <u>2/</u>
1962	1,455,000 <u>1/</u>	6,337,000 <u>2/</u>
1963	1,703,000	6,870,000 <u>2/</u>
1964	1,527,000 <u>1/</u>	8,454,000 <u>2/</u>
1965	1,609,000 <u>1/</u>	8,678,000 <u>2/</u>
1966	1,612,000	9,038,000 <u>2/</u>
1967	2,058,000 <u>1/</u>	8,943,000 <u>2/</u>
1968	1,894,000 <u>1/</u>	9,360,000 <u>2/</u>

1/ The wheat crop has been estimated or reported as follows in recent years:

USDA. 1962, 1.5 million; 1964, 1.9; 1965, 2.1; 1967, 2.3; 1968, 2.2.

FAO. 1964, 2.1 million; 1967, 2.4.

2/ The corn crop has also been estimated or reported as follows:

USDA. 1961, 5.5 million; 1962, 6.4; 1963, 6.4; 1964, 7.5; 1965, 8.0; 1966, 8.2; 1967, 8.5; and 1968, 9.2.

FAO. 1967, 9.3 million.

Sources:

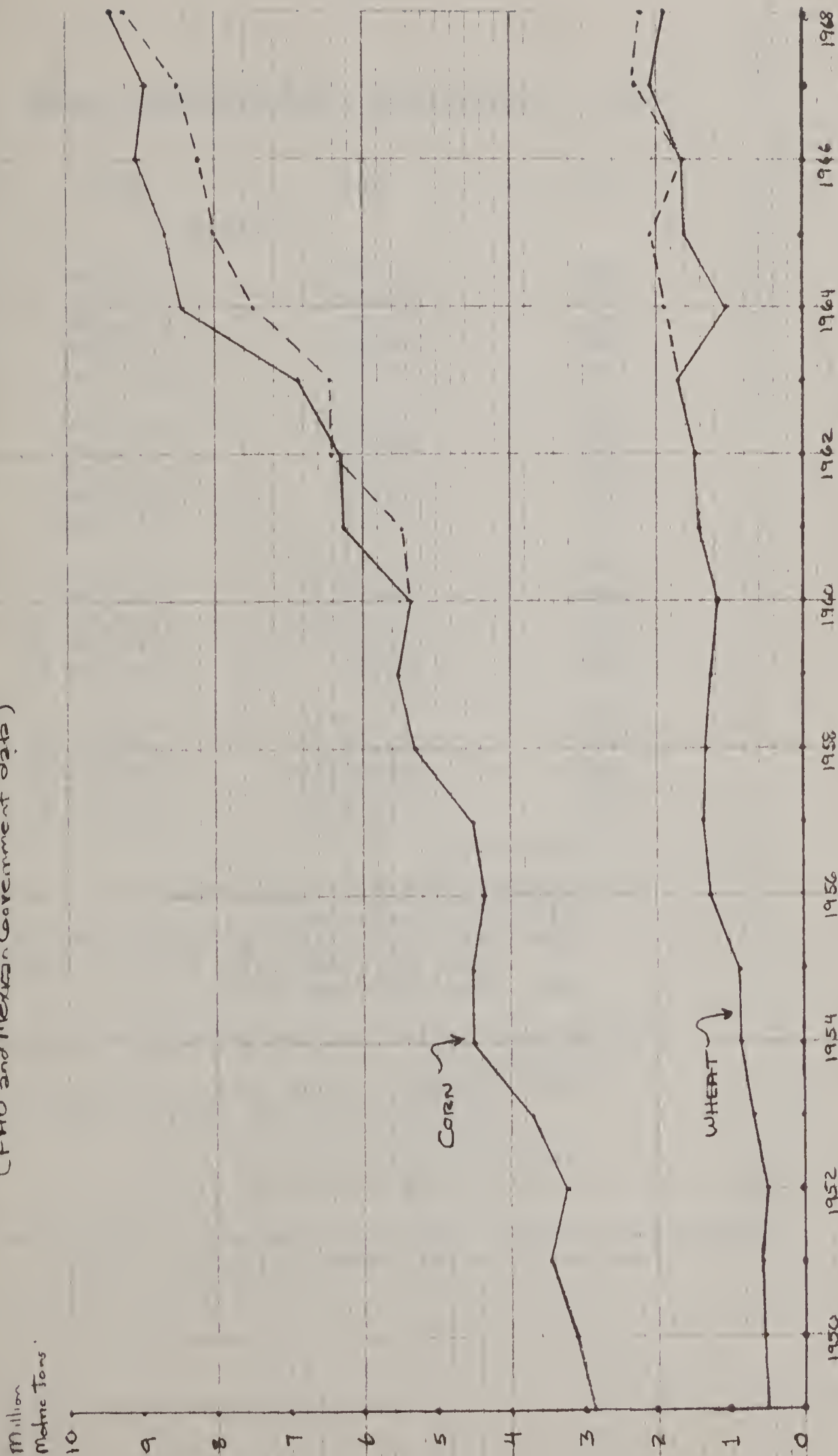
1949-1961. World Crop Statistics, 1966 (FAO), p. 36.

1962-1963. Production Yearbook, 1967 (FAO), p. 36.

1964-1968. Memoria de Labores de la Secretaría de Agricultura y Ganaderia (Mexico City), 1968, pp 117-121.

- (1960-1968) Indices of Agricultural Production for the Western Hemisphere, USDA, ERS Foreign 264, March 1969, p. 26; Ansel Wood, Grain and Feed Division, Foreign Agricultural Service, USDA, April 8, 1969.
- (1964-1968) Monthly Bulletin of Agricultural Economics and Statistics (FAO), December 1968, pp. 20-22.

Figure 1.
ESTIMATED PRODUCTION OF WHEAT AND CORN IN MEXICO
(FAO and Mexican Government data)



Note: Dotted line for 1960 to 1968 is USDA estimate.
Source: Table 1.

Table 2. ESTIMATED AREA OF WHEAT AND CORN IN MEXICO

<u>Year</u>	<u>Wheat</u>	<u>Corn</u>
	-- hectares --	
1949	535,000	3,792,000
1950	644,000	4,328,000
1951	673,000	4,428,000
1952	593,000	4,236,000
1953	657,000	4,863,000
1954	765,000	5,253,000
1955	800,000	5,371,000
1956	937,000	5,460,000
1957	958,000	5,392,000
1958	840,000	6,372,000
1959	937,000	6,324,000
1960	840,000 <u>1/</u>	5,415,000 <u>2/</u>
1961	837,000 <u>1/</u>	6,288,000 <u>2/</u>
1962	748,000	6,372,000 <u>2/</u>
1963	819,000	6,963,000 <u>2/</u>
1964	743,000 <u>1/</u>	7,461,000 <u>2/</u>
1965	683,000 <u>1/</u>	7,718,000 <u>2/</u>
1966	682,000 <u>1/</u>	8,287,000 <u>2/</u>
1967	762,000 <u>1/</u>	7,584,000 <u>2/</u>
1968	717,000 <u>1/</u>	7,800,000 <u>2/</u>

1/ The wheat area has also been estimated or reported as follows in recent years:

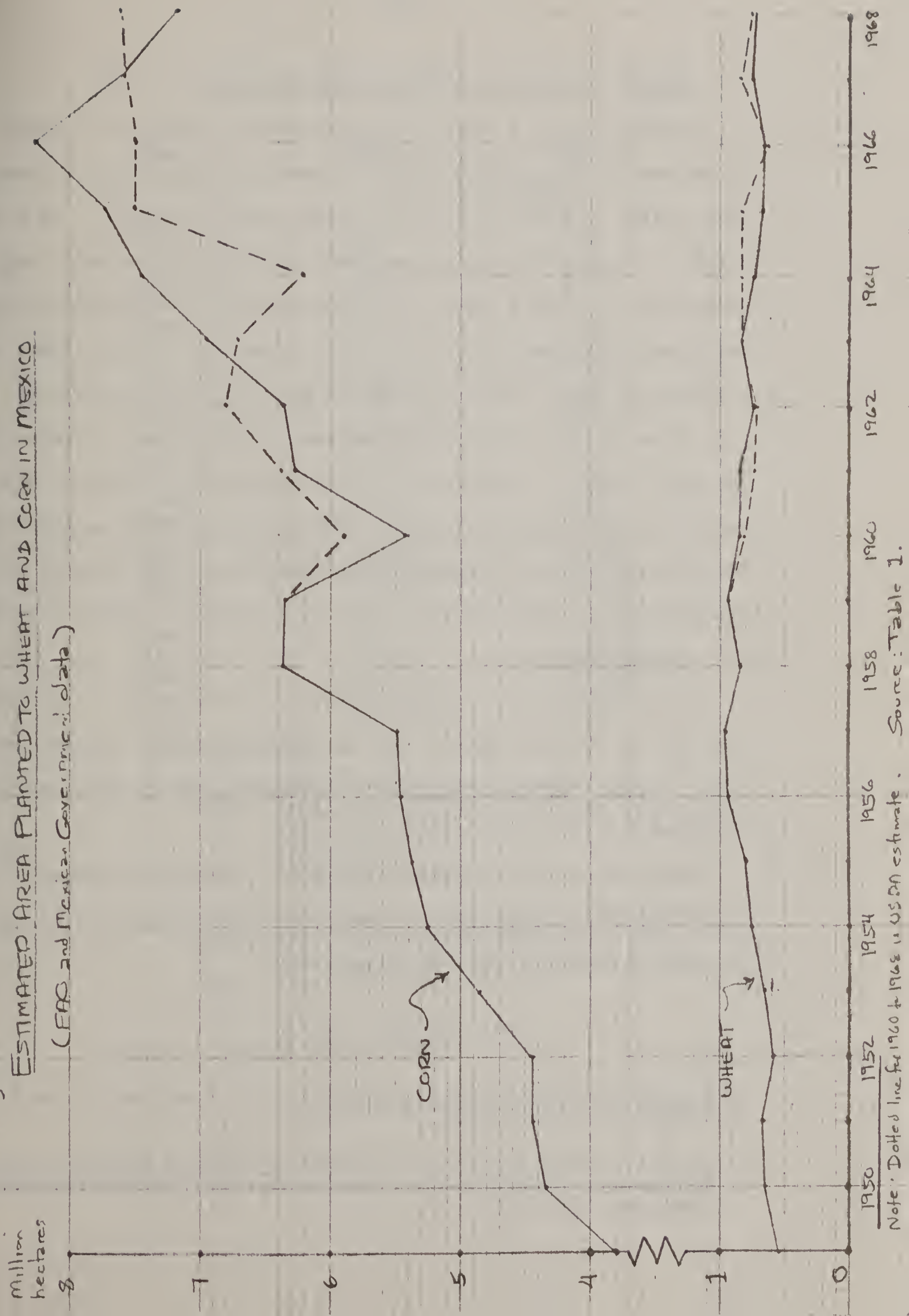
USDA. 1960, 0.82 million; 1961, 0.74; 1964, 0.84;
1965, 0.83; 1966, 0.64; 1967, 0.86; 1968, 0.75.
FAO. 1964, 0.83; 1967, 0.86.

2/ The corn area has also been estimated or reported as follows:

USDA. 1960, 5.9 million; 1961, 6.4; 1962, 6.8;
1963, 6.7; 1964, 6.2; 1965, 7.5; 1966, 7.5;
1968, 7.6.
FAO. 1966, 7.7 million; 1967, 7.7.

Sources: Same as Table 1 except for USDA data for 1960 to 1966 which was provided by Mary Conyer of FAS, May 1, 1969.

Figure 2.
ESTIMATED AREA PLANTED TO WHEAT AND CORN IN MEXICO
(FAO and Mexican Government data)



C. Yields

Average yields of wheat and corn in Mexico in 1968, as reported by the Foreign Agricultural Service, presented a mixed picture. Average wheat yields of about 2.9 tons per hectare were the highest -- by a wide margin -- in Latin America and are even above the U.S. average. Corn yields are a different matter: Mexico's yield of tons per hectare ranked only sixth among Latin American nations in 1967 and tied for eighth over the 1960-64 period.^{3/} Wheat yields were more than twice corn yields.

In any case, yields of wheat and corn in Mexico have increased over the past 20 years. The increase, as revealed by FAO and Mexican Government data, was sharpest for wheat: 1968 yields were more than 150% higher than 1949. Corn yields increased more moderately: 1968 yields were only about 60% higher than in 1949. Details are provided in Figure 3 and Table

D. Relative Roles

In total, we can see that while output of both wheat and rice increased from 1949 to 1968, it appears that the expansion was due to different factors: in wheat it was largely due to yields; in corn it was largely due to increased area.

Verification of this point is provided by Venezian and Gamble.^{4/} They calculated that over the period from 1949-51 to 1962-64, the relative importance of each factor was as follows:

(text continued on p. 9)

^{3/} World Agricultural Production and Trade, U.S. Department of Agriculture, November 1968, pp. 18, 22.

^{4/} Eduardo Venezian and William K. Gamble, A Review of Mexican Agricultural Development, 1950-1965, Cornell University, International Agricultural Mimeograph 16, p. 13.

Table 3. ESTIMATED YIELDS OF WHEAT AND CORN IN MEXICO

<u>Year</u>	<u>Wheat</u>	<u>Corn</u>
	--tons per hectare--	
1949	0.94	0.76
1950	0.91	0.72
1951	0.88	0.77
1952	0.86	0.76
1953	1.02	0.76
1954	1.10	0.85
1955	1.06	0.84
1956	1.33	0.80
1957	1.44	0.83
1958	1.59	0.83
1959	1.35	0.88
1960	1.42	0.99
1961	1.68 <u>1/</u>	0.99
1962	1.95 <u>1/</u>	0.99 <u>2/</u>
1963	2.08 <u>1/</u>	0.99 <u>2/</u>
1964	2.06 <u>1/</u>	1.13 <u>2/</u>
1965	2.35 <u>1/</u>	1.12 <u>2/</u>
1966	2.40 <u>1/</u>	1.09 <u>2/</u>
1967	2.70	1.18 <u>2/</u>
1968	2.64 <u>1/</u>	1.20

1/ The wheat yield has also been reported as follows:

USDA. 1960, 1.46 million; 1961, 1.90; 1962, 2.04;
1963, 2.09; 1964, 2.28; 1965, 2.51; 1966, 2.53;
1968, 2.93.

FAO. 1964, 2.57 million.

2/ The corn yield has also been reported as follows:

USDA. 1961, 0.85 million; 1962, 0.95; 1963, 0.96;
1964, 1.21; 1965, 1.07; 1966, 1.09; 1967, 1.12.

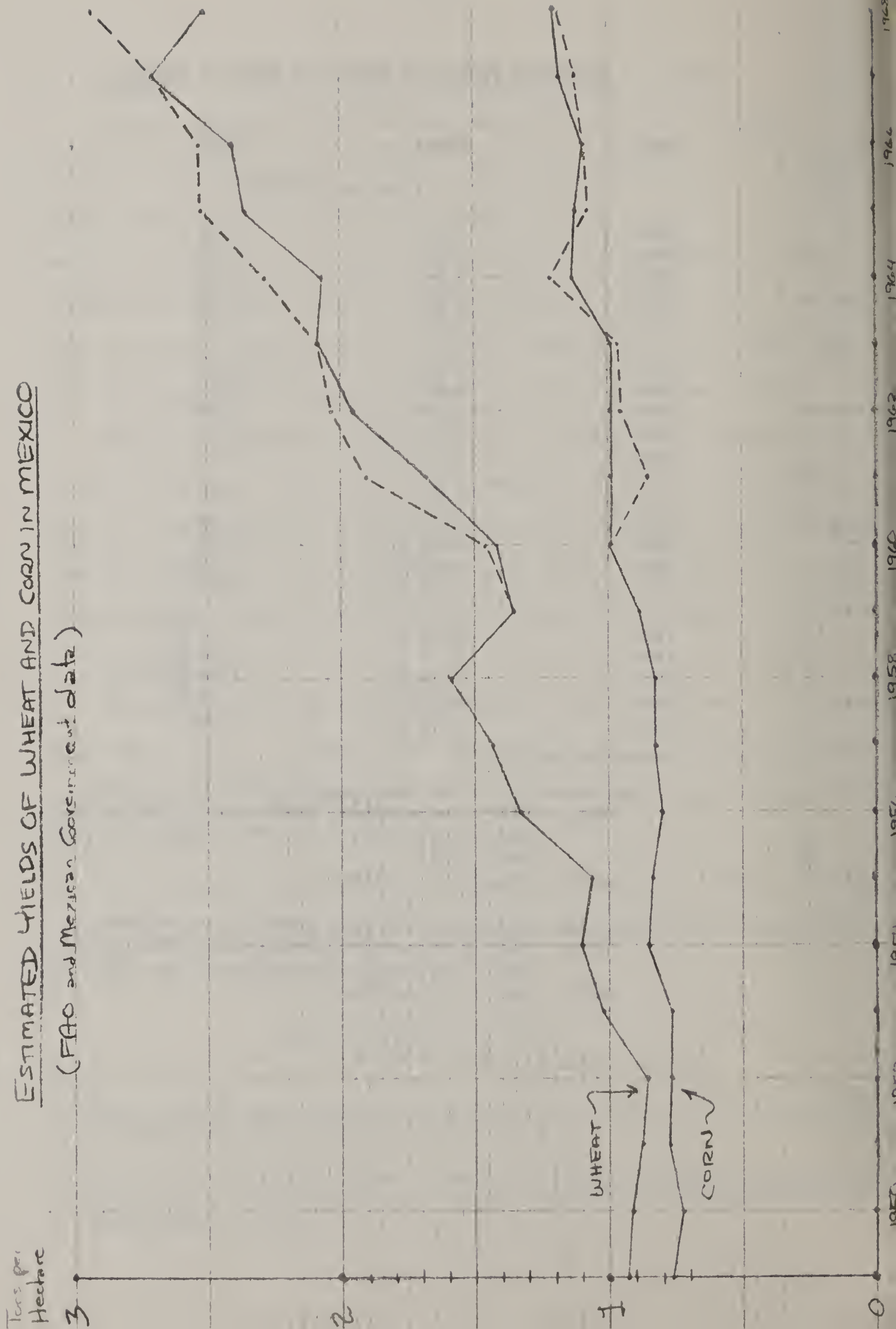
FAO. 1966, 1.18 million.

Sources: Same as Tables 1 and 2.

Figure 3.

ESTIMATED YIELDS OF WHEAT AND CORN IN MEXICO

(FAO and Mexican Government data)



	<u>Wheat</u>	<u>Corn</u>
	-- percent --	
Area Expansion	15	55
Yield Increase	51	25
Area and Yield*	34	20
	<u> </u>	<u> </u>
TOTAL	100	100

* Result of yield increases on new land

In the remainder of this report we shall concentrate on the factors contributing to increased yield.

II. FACTORS CONTRIBUTING TO INCREASED YIELD

A. Purchased Inputs

The main inputs responsible for the increase in yield are improved seeds, irrigation, and fertilization.

1. Improved Seed

Improved varieties of wheat and corn have, of course, played a significant role in the increase of yields per hectare. Mexico was the first developing nation to benefit from improved varieties. Although precise figures are lacking, it appears that the area sown to such varieties by 1965 averaged about 800,000 hectares for wheat and 720,000 hectares for corn. The area sown to improved wheat varieties increased very rapidly from 1949 to 1958, then levelled off and subsequently, declined somewhat. The area sown to improved corn expanded much more slowly until the early 1960's, when it increased sharply. Details are provided in Table 4 and Figure 4.

Although the areas planted to improved wheat and corn varieties were much the same by 1963, they represented quite different proportions of total area. The improved wheat varieties accounted for over 90% of total wheat area by 1957, while it was not until 1963 that the area of improved corn exceeded 10% of the total area. (For details, see Table 5 and Figure 5). These adoption rates go a long way toward explaining the differences in the crop yields reflected in Table 3 and Figure 3.

It is not entirely clear, however, how yields of improved varieties of wheat and corn compare with each other or with unimproved varieties. On the whole, Myren suggests that while wheat outyields corn on irrigated

(text continued on p. 15)

Table 4. ESTIMATED AREA PLANTED TO IMPROVED VARIETIES OF
WHEAT AND CORN IN MEXICO
(three-year moving averages)

<u>Year</u>	<u>Wheat</u>	<u>Corn</u>
	--hectares (rounded)--	
1949	40,000	81,000
1950	68,000	131,000
1951	109,000	150,000
1952	171,000	150,000
1953	277,000	170,000
1954	415,000	215,000
1955	577,000	259,000
1956	714,000	226,000
1957	779,000	199,000
1958	820,000	272,000
1959	808,000	326,000
1960	808,000	296,000
1961	754,000	364,000
1962	747,000	512,000
1963	731,000	736,000
1964	775,000 <u>2/</u>	734,000
1965 <u>1/</u>	807,000 <u>2/</u>	720,000

1/ 1965 only; not moving average.

2/ The estimates reported here for improved wheat in 1964 and 1965 is (1) larger than the total estimate reported by the Mexican government in Table 2, but (2) smaller than the USDA estimate reported in footnote 1 to Table 2.

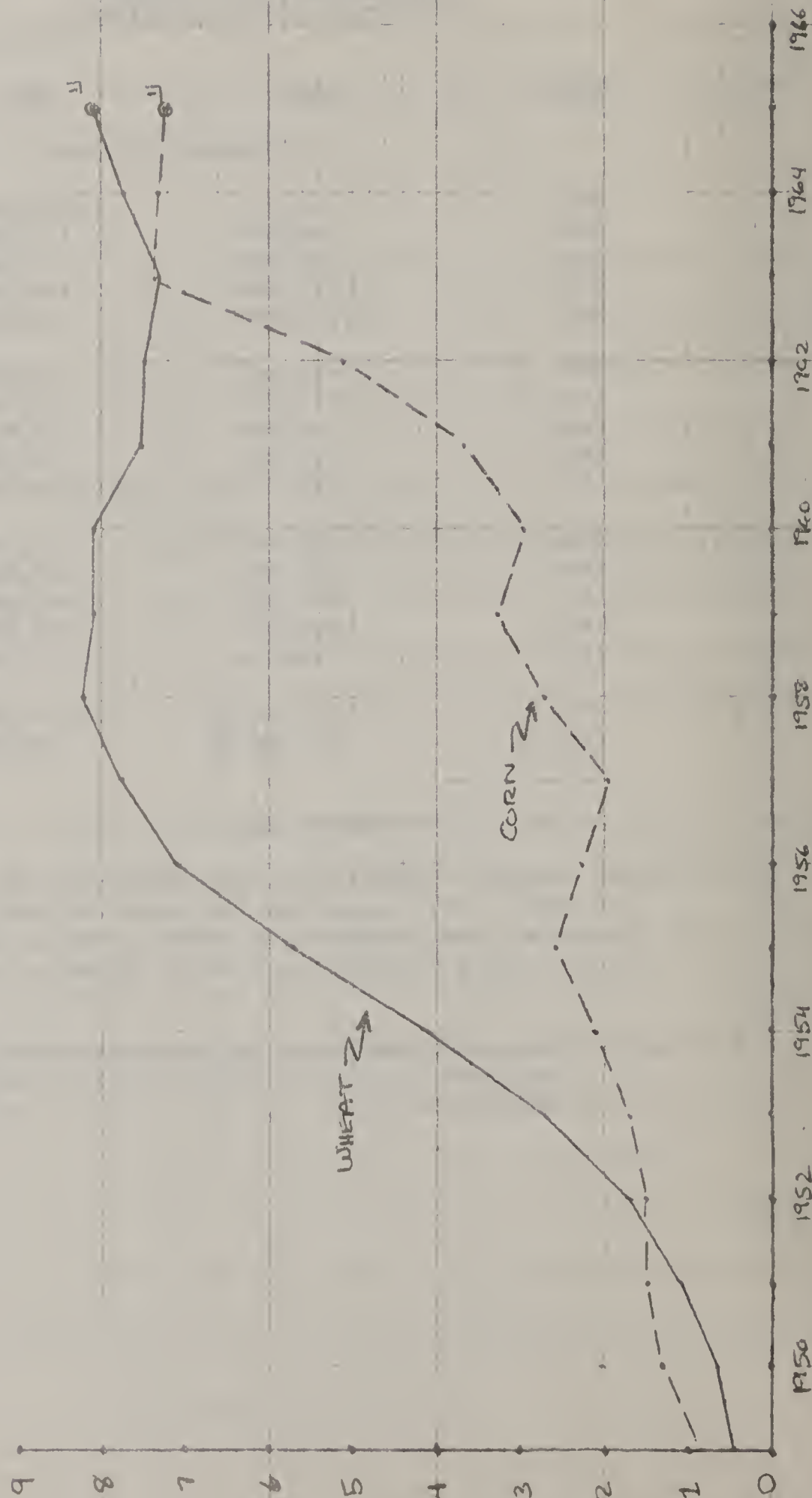
Source: Computed from yearly estimates provided by Reed Hertford, Economic Research Service, USDA, March 1969.

Figure 4. ESTIMATED AREA PLANTED TO NEW VARIETIES OF

WHEAT AND CORN IN MEXICO

(three-year moving average)

Hundred
Thousand
Hectares



Note: 1965 only; not moving average. Source: Table 4.

Table 5. ESTIMATED PROPORTION OF TOTAL AREA OF WHEAT AND CORN DEVOTED TO NEW VARIETIES, MEXICO

<u>Year</u> ^{<u>1/</u>}	<u>Proportion of Area Harvested</u> ^{<u>2/</u>}	
	<u>Wheat</u>	<u>Corn</u>
	--percent--	
1949	7.7	1.4
1950	11.8	2.3
1951	17.9	2.5
1952	28.3	2.8
1953	43.5	2.8
1954	60.0	3.4
1955	77.0	4.1
1956	87.7	3.5
1957	92.7	3.1
1958	93.9	4.1
1959	94.1	4.8
1960	97.7	4.4
1961	96.1	5.6
1962	96.2	8.0
1963	95.1	11.8
1964	89.7	12.6
1965 ^{<u>3/</u>}	89.1	13.0

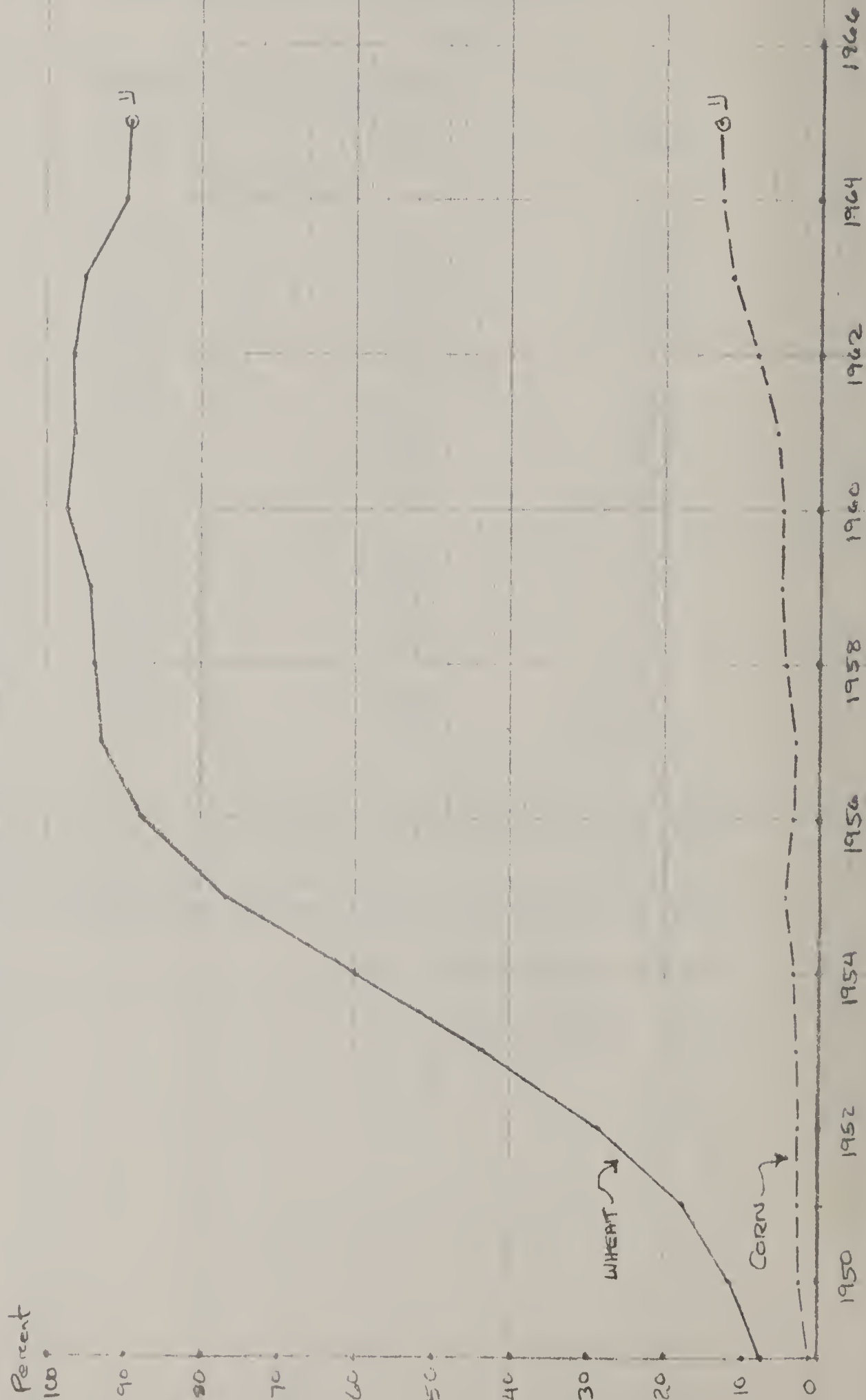
1/ Three-year moving average for area in new varieties; annual data for total cropland.

2/ The data for total wheat area used in making this calculation were not necessarily the official Mexican figures.

3/ 1965 only; not moving average.

Source: Same as Table 4.

Figure 5. ESTIMATED PROPORTION OF TOTAL AREA OF WHEAT
AND CORN DEVOTED TO NEW VARIETIES



Note: 1965 only; and moving average. Source: Table 5

land, the reverse may be true under residual moisture. The increase in yield associated with the improved wheats was higher than for corn. Moreover, continued breeding efforts with wheat have raised average yields of current varieties to more than twice those existing in 1950.^{1/}

There is, strangely, little further statistical information available on the use of the new varieties. This statistical gap is particularly curious when it is realized that all seed multiplication and distribution is handled by the Mexican government--through an organization known as PRONASA (Productora Nacional de Semillas, S.A.).

Stakman, Bradfield and Mangelsdorg indicate that government involvement is one reason why improved corn has not moved more rapidly.

---once hybrid corn became established on the larger farms managed by the more progressive farmers, the expansion slowed down. Hybrid corn is not yet reaching the small farmer in Mexico in substantial amounts, and it probably never will until private enterprise is allowed a part in its promotion. ^{2/}

A slightly different perspective is provided by Hicks:

It was necessary to develop a specific hybrid for each of the many different corn producing areas whereas a single wheat variety was found to be suited to large areas of Mexico. The fact that corn is open pollinated (while wheat is self pollinated) created problems in distributing the seed and maintaining the vigor of the hybrid corn year after year. ^{3/}

There is, however, more than a question of seed breeding and distribution involved. Perhaps the biggest single factor is the availability of water.

^{1/} Myren, op. cit. (see Preface). Wheat farmers have changed varieties at least half a dozen times.

^{2/} Stakman, Bradfield and Mangelsdorf, op. cit. (see Preface), pp. 70-71.

^{3/} W. Whitney Hicks, "Agricultural Development in Northern Mexico, 1940-1960," Land Economics, November 1967, p. 401. This point is discussed in greater detail by Myren, op. cit.

2. Irrigation

The life blood of the improved varieties in Mexico is provided by water. Data is not available directly showing the proportion of the improved seeds grown under irrigation, but it is probably relatively high. This relationship is suggested in an indirect way by a comparison of the area of new varieties of wheat and corn and the area devoted to these crops in the irrigation districts in 1965. ^{4/}

	<u>New Varieties</u>	<u>Irrigation Districts</u>
	--hectares--	
Wheat	<u>807,000</u>	<u>552,552</u>
Corn	720,000	515,800

It would be only logical to expect the irrigated areas to be largely planted to new varieties. If the irrigated area were entirely so planted, it would represent about 70% of the high-yielding variety area.

The relationship with new varieties is further suggested by an examination of the role irrigation districts play in overall grain production. In 1965, nearly 95% of Mexico's wheat and over 13% of its corn was raised in irrigation districts. In terms of area, the districts accounted for over 80% of the wheat land and nearly 7% of the corn land; this figure ties in closely with the percentages reported for new varieties in Table 5 (89 and 13% respectively). Yields in the irrigation districts were higher than for the country as a whole -- nearly twice as high for corn (the percentage increase for wheat was small, reflecting the fact that nearly all of it is raised on irrigated land). Details are provided in Table 6.

^{4/} Within the irrigation districts, essentially all of the wheat is provided regular irrigation, but only about 83% of the corn is regularly irrigated, 11% is partially irrigated and the remaining 6% receives rainfall only.

TABLE 6. ESTIMATED AREA AND PRODUCTION
OF WHEAT AND CORN WITHIN
IRRIGATION DISTRICTS, MEXICO, 1965

A. Production

	<u>Total Crop</u> <u>Production</u>	<u>Production in</u> <u>Irrigation Districts</u>	<u>Proportion of Production</u> <u>in Irrigation Districts</u>
	--metric tons --		
Wheat	1,609,000	1,523,746	94.7%
Corn	8,678,000	1,143,121	13.2

B. Area

	<u>Total Crop</u> <u>Area</u>	<u>Area in</u> <u>Irrigation Districts</u>	<u>Proportion of</u> <u>Cropland in</u> <u>Irrigation Districts</u>
	--hectares--		
Wheat	683,000	552,552	80.8%
Corn	7,718,000	515,800	6.7

C. Yield

	<u>Overall Yield</u> <u>Average</u>	<u>Yield in</u> <u>Irrigation Districts</u>	<u>Increase in</u> <u>Yield</u>
	--tons per hectare--		
Wheat	2.35	2.76	+17%
Corn	1.12	2.22	+98

Sources:

Total data: Tables 1-3

Irrigation Districts: Estadística Agrícola del Ciclo 1964-1965,
Secretaría de Recursos Hidráulicos (Mexico, D.C.), Informe
Estadístico Num 32, October 1966, pp. 258-260.

Irrigation districts within certain states are particularly important in grain production. Irrigated wheat area and production was concentrated as follows in 1965:

<u>State</u>	<u>Area</u>	<u>Production</u>
	--hectares--	--tons--
Sonora	292,300	806,200
Baja California	73,900	141,500
Sinaloa	58,900	168,300
Guanajuato and Michoacan	38,600	101,400
	<u>463,700</u>	<u>1217,700</u> (1,600,000)

Together the five States accounted for 80% of irrigated wheat production and 76% of all Mexican wheat production. Leading irrigated corn producing states were Tamaulipas, Guanajuato and Michoacan; together irrigation districts in the three States accounted for 57% of corn production in all irrigation districts, but only 7.6% of national corn production. Presumably the use of new varieties tends to be similarly concentrated.

The geographic location of these States is indicated in Figure 6. In the case of wheat, the three leaders are in the Pacific North; the three leading irrigated corn states are in the central portion of the country (two in the Central Region and one just to the northeast in the North Region). Of the new land put under irrigation by the government during the 1947 to 1960 period, 46% was in the Pacific North, 27% in the North and 20% in the Central Regions. ^{5/}

Changes in these regions during the 1949-51 to 1962-64 period are presented in Table 7. It will be noted that virtually all of the increases in area and production of wheat was found in the Pacific North

(text continued on p.21)

^{5/} Venezian and Gamble, op. cit., p. 16.

NEW VARIETIES IN MEXICO: WHEAT, CORNERRATA AND ADDENDAErrata

-Page 21, paragraph 3. Lines 2 to 6 should read as follows:

Moreover, water is supplied at minimal expense: the government receives only a little over half of its operating costs from user fees (which recently have run about \$16 per hectare per year). In addition to water, the farmers also receive "...advice on

-Page 30, paragraph 1, line 3. "rick" should read "risk".
line 4. "quire" should read "quite"

Addenda

-Page 30, paragraph 2. Item 3 (credit) should read as follows:

Little information is available on the use of credit. Freebairn notes that is is "...channeled into the same areas as those served by the public water resource agencies."^{22/} Myren suggests a further dimension:

The banks give preference to the larger operators and to the irrigated areas where there is less risk of crop failure. The crop insurance agency cooperates by insuring these loans, and the price-support agency purchases the harvest. Those who do not get credit from the agricultural banks generally do not participate in the other two programs.^{23/}

The result of this cycle is that the gap between the modern and traditional sectors in Mexico is widened yet further.

^{22/} Freebairn, op. cit., p. 37.

^{23/} Delbert T. Myren, Integrating the Rural Market into the National Economy of Mexico, University of Wisconsin, Land Tenure Center, No. 46, June 1968, p. 5. (Translation of article appearing in Comercio Exterior, September 1967).

Figure 6. MEXICAN STATE AND REGIONAL BOUNDARIES



TABLE 7. PROPORTION OF TOTAL INCREASE IN AREA AND PRODUCTION OF WHEAT AND CORN BY REGION, 1949-51 to 1962-64, MEXICO

<u>Region</u>	<u>Wheat</u>		<u>Corn</u>	
	<u>Area</u>	<u>Production</u>	<u>Area</u>	<u>Production</u>
	-- percent --			
1. North	- 37	3	13	12
2. Gulf	- 1	0	20	20
3. North Pacific	187	85	2	5
4. South Pacific	- 2	0	14	11
5. Central	- 47	12	52	54
<hr/>				
TOTAL	100	100	101 <u>1</u> / ₂	102 <u>1</u> / ₂

1/₂ Totals do not add to 100% because of rounding error.

Source: Eduardo Venezian and William K. Gamble, A Review of Mexican Agricultural Development, 1950-1965, Cornell University, International Agricultural Development Mimeograph 16, pp. 6-7.

while the increases for corn were more widely spread, though most pronounced in the Central Region. As for changes in yield, the most pronounced increases, for both wheat and corn, were found in the Pacific North, followed by the Central Region. ^{6/}

There is a strong tendency for the newly irrigated areas to lie in the less highly populated regions in the country (in part because of the location of water resources). Freebairn notes that the total number of water users in formally organized irrigation districts was no more than 340,000 in 1965--or less than 15% of all the farmers in the country.

Despite the small number of users, "irrigation investments have been over 90% of all direct public investments in agriculture." ^{7/} Moreover, water is supplied at minimal expense: Moreover, the government receives only a little over half of its operating costs are covered by user, costs which recently have run about \$16 per year per hectare. In addition to water, the farmers also receive "...advice on proper irrigation practices, meteorological information, soil analysis, and fertilizer and soil conservation practices." ^{8/}

Clearly, those farmers with irrigation are few and favored.

^{6/} Venezian and Gamble, op. cit., p. 16.

^{7/} Donald K. Freebairn, "The Dichotomy of Prosperity and Poverty in Mexican Agriculture, "Land Economics", February 1969, p. 36.

^{8/} Robert S. Firch and Robert A. Young, An Economic Study of the Winter Vegetable Export Industry of Northwest Mexico, University of Arizona, Agricultural Experiment Station, Technical Bulletin 179, October 1968, p. 14. (source of quote): Wade F. Gregory, "Agricultural Development in Greece, Mexico and Taiwan," U.S. Department of Agriculture, Economic Research Service, September 1967, p. 12.

3. Fertilizer and Machinery

The total use of fertilizers and insecticides in Mexico has expanded sharply since 1950. The magnitude of this growth is indicated in the following estimates of consumption.^{9/}

	<u>Fertilizer</u>	<u>Insecticides</u>
	-- tons --	
1950	12,400	14,100
1955	78,500	97,800
1960	196,700	113,600
1993	308,700	121,700

It is not known what proportion of these totals was used on wheat and corn.

Information is available, however, on the use of fertilizers and machinery on all irrigated crop land. For reasons discussed in previous sections, irrigation data may to some extent be considered a surrogate for variety data.

Estimates assembled by Reed Hertford of the Economic Research Service indicate that in the early 1960's, the extent of fertilization and mechanization on irrigated land was considerably higher than the average for all cropland. In the case of irrigated land, 64% was fertilized and 79% was fully or partially mechanized. The comparable figures for all cropland, including irrigated, were 21 and 29%. The levels for non-irrigated land would, of course, be lower than for

^{9/} Francis S. Urban, Summary and Evaluation of "Supply and Demand for Agricultural Products in Mexico to 1965, 1970, and 1975," U.S. Department of Agriculture, Economic Research Service, ERS-Foreign 208, January 1968, p. 51.

all cropland. ^{10/}

A further indicator for fertilizer is the fact that in 1965, about 68% of the total quantity of nitrogen, phosphate and potassium was used on irrigated land ("riego") -- not just crop land in the irrigated districts (see fn. 4, p. 16). ^{11/}

Thus, use of fertilizer and machinery is probably heavily concentrated on new varieties in irrigation districts.

B. Government Policies

Aside from the clear government emphasis on irrigation, what other policies help bring about the increase in yields?

1. Promotional Programs

In some countries the government has carried out a strong promotional campaign for the new varieties. This does not seem to have been the case in Mexico. Freebairn indicates that in the case of wheat there was no highly organized dissemination program:

...the research results were picked up with considerable effectiveness by the relatively small number of wheat farmers...^{12/}

Much the same appears to have been true of the large corn growers.

We shall return to this matter later.

^{10/} Reed Hertford, "The Measured Sources of Growth of Mexican Agricultural Production and Productivity," Economic Research Service, U.S. Department of Agriculture, December 1968, p. 76 (unpublished manuscript).

^{11/} Special calculation by Hertford, March 31, 1969.

^{12/} Freebairn, op. cit., p. 40.

2. Price Programs

On the other hand, the government does have a price policy program which appears to have provided a stimulus to production. The program has been carried out since 1959 by a government agency known as CONASUPO (Compania Nacional de Distribucion de Subsistencias Populares).

- Wheat. The support price has remained at 913 pesos (\$73) per metric ton since 1959; in the mid-1960's however, the support price in the three leading producing areas (irrigated districts in the States of Sonora, Sinaloa and Baja California) was lowered to 800 pesos (\$64) per ton (premiums of 20-30 Pesos are paid for durum and semi-hard wheats).

- Corn. The support price was 800 pesos (\$64) per ton from 1959 to 1962; in 1963 this was raised to 940 pesos (\$75) per ton. In 1965 the support price was changed to apply only to non-irrigated corn: the support price for irrigated corn was set at 800 pesos (\$64) per ton.

Thus there is now a two-price support system in Mexico, with a lower price being paid for wheat and corn in the more favored areas. Not all production, of course, is covered by this program; in 1962 the government purchased nearly 69% of the wheat production but only 12% of corn production. 13/

13/ Foreign Agricultural Service report from Mexico City, MX 9008, February 7, 1969, March 28, 1969; World Wheat Statistics, International Wheat Council, London, Table 19, annual issues; L. B. Fletcher and B. L. Sanders, "The Effects of Agricultural Pricing Policies in Mexico on Basic Subsistence Commodities", prepared for the Economic Research Service (manuscript), pp. 12-15.

The basic reason that supports were lowered was that surplus production was developing. In fact, Mexico suddenly found itself exporting -- rather than importing -- wheat and corn by 1964 (see Table 8). This would have been fine except that the support prices, according to a 1967 report, made the selling price too high to compete on the export market: support prices and export subsidies meant government losses. The reduction of support prices in the most productive areas did lead to a certain tapering off of production and exports but was not entirely successful: the lowering of price supports on irrigated corn led to an increase in production in non-irrigated areas -- which was aided by favorable weather.^{14/}

How do Mexican support prices compare with those of other developing nations? On balance, it appears that at official rates of exchange they are relatively low for wheat, but high for corn. At unofficial exchange rates, the support price for wheat in several Asian nations drop below Mexican levels. Details are provided in Table 9.

When the comparison, however, is drawn with international prices, both sets of Mexican prices are high (in some cases, however, this is in part because the other nations have provided export subsidies). During 1960, the situation was as follows: the Mexican support price for wheat of \$73/ton compared with landed or c.i.f. prices of American and Australian wheat in the U.K. of around \$70/ton; the support price for corn of \$75/ton compared to landed prices of American and Argentine corn of around \$60/ton in the U.K.^{15/}

(text continued on p.28)

^{14/} John C. Scholl, "Mexico's Grain Problem: A Production Boom That Won't Turn Off", Foreign Agriculture, July 3, 1967, p. 7.

^{15/} Computed from data reported in Foreign Agricultural Trade of the United States, U.S. Department of Agriculture, April 1969, pp. 26-27.

TABLE 8. NET IMPORT AND EXPORT BALANCES
FOR WHEAT AND CORN, MEXICO

<u>Year</u>	<u>Wheat</u>	<u>Corn</u>
(- = imports; + = exports)		
-- metric tons --		
1951	- 364,400	- 118,000
1952	- 439,600	- 24,400
1953	- 242,000	- 372,600
1954	- 62,200	- 144,700
1955	- 9,500	+ 57,700
1956	- 84,600	- 122,800
1957	- 100	- 810,800
1958	0	- 807,300
1959	0	- 32,400
1960	0	+ 448,900
1961	0	- 8,200
1962	+ 500	- 78,800
1963	+ 72,300	- 448,100
1964	+ 556,100	+ 250,300
1965	+ 683,400	+ 1,335,600
1966	+ 47,700	+ 848,200
1967	+ 187,700	+ 1,121,300
1968	+ 89,000	+ 892,100

Source: 1951-1966. FAO Trade Yearbooks.
1967-1968. Grain Division, Foreign Agricultural Service, USDA.

Table 9. GOVERNMENT SUPPORT OR PURCHASE PRICE FOR WHEAT AND CORN
IN LESS-DEVELOPED NATIONS, 1968
(At Official and Free Rates of Exchange)

<i>wheat</i>			<i>corn</i>		
<u>Country</u>	<u>Official</u>	<u>Free</u>	<u>Country</u>	<u>Official</u>	<u>Free</u>
-- dollars per metric ton, rounded --					
Mexico	73 <u>1</u> /	--	Mexico	75 <u>3</u> /	--
Brazil	88 ✓	--	Brazil	47	--
Colombia	126 ✓	116	Kenya	43	34
Paraguay	80 ✓	78	Thailand	47	--
Morocco	79 ✓	71	-----		
Turkey	87 ✓	59	United States	50 <u>4</u> /	--
Pakistan	96 ✓	53			
India	101 ✓	72			

United States	97 <u>2</u> /	--			

Notes:

- 1/ Except for price of \$64/ton in Sonora, Sinaloa, and Baja California.
- 2/ Loan rate (\$46) plus certificate (\$57).
- 3/ Unirrigated area; \$64/ton in irrigated area.
- 4/ Loan price (\$39) plus support payment (\$11).

Sources:

Derived from Foreign Agricultural Service attache reports and exchange rates published in Picks Currency Yearbook, 1968. U. S. prices derived from data provided by W. H. Kastens, Statistical Reporting Service, USDA.

Mexico is well aware of the problem of competing against these prices. One calculation of the "...loss incurred through over-production /of corn/ with the resulting necessity to export in 1967-68 is...about 2.5 billion Pesos (\$200 million)."^{16/} Whether the actual figure was that high may be questionable, but there is little question that export problems are the main reason for trying to hold production back.

C. Institutions

The main institutions which we will briefly deal with here concern research, education and credit.

1. Research

The main research work was, of course, originally carried out by the Rockefeller Foundation under its International Wheat Program and International Corn Program. These efforts were united in 1966 with the establishment of the International Maize and Wheat Improvement Center (CIMMYT - Centro Internacional de Mejoramiento de Maiz y Trigo) in Chapingo, Mexico. The Center is now jointly financed by the Rockefeller and Ford Foundations. Cooperative programs are carried out with the Mexican government. ^{17/}

The principal Mexican institution responsible for agricultural research is the Instituto Nacional de Investigaciones Agrícolas (INIA). It was created in 1960 out of programs of the Office of Special Studies supported by the Rockefeller Foundation and a former agricultural research institute. ^{18/}

^{16/} FAS report MX 9019, op. cit.

^{17/} For background, see the references listed in the Preface of this report.

^{18/} Venezian and Gamble, op. cit., p. 24.

In looking back on the research efforts for wheat and corn, Wortman indicates that the wheat effort was more comprehensive than that for corn: the wheat program was not only with breeding "... but with seed production, the use of higher amounts of fertilizer, and adoption by farmers." By contrast the need to develop the many types of corn hybrids for the varying ecological conditions led to a preoccupation with breeding. ^{19/}

CIMMYT currently has a cooperative program under way to increase corn production under unirrigated conditions in the State of Puebla; another program is under way in the Chapingo area. ^{20/}

2. Education

Although the research phase of the grains program has been a model for other nations, the same cannot be said of the educational program at the farm level. The foundations have, in the main, not been directly involved in extension. The matter has been largely left to the Mexican government. The government, in turn, did not do very much for wheat -- it didn't need to: the big growers pretty much picked up the new varieties on their own. An emergency plan was established in 1954 to stimulate corn production in the Bajio; this was expanded to a national program in 1965. ^{21/} Just how successful this program was is a moot point. Evidently there was a severe shortage of adequately trained workers. Moreover, the task was severe due to the large number of small growers and the problems

^{19/} Myren, op. cit.

^{20/} CIMMYT News, January-February 1968, and November-December 1968.

^{21/} Myren, op. cit.

of distributing hybrid seed. Also, the fact that success with the improved varieties was heavily dependent on adequate rainfall meant a high degree of risk and uncertainty. In any case, wheat and corn illustrate quite different educational problems.

3. Credit

Little information is available on credit beyond Freebairn's comment that "...credit is channeled into the same areas as those served by the public water resource agencies." ^{22/}

^{22/} Freebairn, op. cit., p. 37.

III. SUBSTITUTION EFFECTS

What changes have taken place in the production pattern for crops with the introduction of the new varieties of wheat and corn? The answer is more clear-cut than might be expected.

The sharp increase in production of wheat, and to a lesser extent of corn, led the Mexican government to search out ways of keeping supply in line with demand. One way of doing this, as we have seen, was to reduce support prices in the more productive areas. This was paralleled by a program to make other crops -- chiefly sorghum and safflower -- more profitable. A support program was established for sorghums in 1961 and for safflower in 1966. The sorghum support price was raised from a level of 525 - 560 pesos in various regions to 625 pesos (\$50) per ton in 1966.^{1/}

The U. S. agricultural attache in Mexico City has recently reported that "...an increased amount of sorghum is being produced on lands formerly planted to corn or wheat." The amount of land being moved out of corn or wheat is difficult to estimate because (1) land formerly planted to other crops (especially cotton) is involved, and (2) there has been a concurrent increase in double cropping involving sorghums. Still, it is evident that there was a decrease in wheat area in 1969; furthermore, it was reported in early 1969 that corn land in the Bajio area (Central Mexico) and in northern Tamaulipas (North Region) was being reduced.^{2/}

^{1/} Fletcher and Sanders, op. cit., p. 13.

^{2/} Based on the following Foreign Agricultural Service reports from Mexico: MX 121, September 12, 1968; MX 9008, February 2, 1969; and MX 9019, March 28, 1969.

The result, in any case, has been a sharp increase in the area planted to sorghum -- from 276,000 hectares in 1964 to an estimated 680,000 hectares in 1968 (the increase in production during the same period has been even more striking -- from 226,000 tons to 1.7 million).^{3/} The support program for sorghum has evidently stimulated production for use in animal feeds.^{4/}

Other shifts are possible but cannot be answered with information at hand. It is not clear what the degree of substitution is between wheat and corn in irrigated areas; Myen notes that "...corn can be grown successfully wherever wheat is currently produced although in most places not during the same growing period."^{5/} It is also not clear whether there is much substitution between grains and the important winter vegetable crops in the Pacific North: one report suggests that the net returns for growing wheat in Sinaloa are only a fraction of those received from vegetables; yet another report indicates that only about 5% of the irrigated area in Sinaloa is planted to vegetables and that this amount is little affected by the area planted to other crops.^{6/}

In any case, the switch to sorghum, while not fully documented, is still probably one of the clearest examples of substitution among crops in less developed nations. Still to be fully reported are shifts involving other crops.

^{3/} Memoria de Labores, op. cit., p. 117. The USDA estimate for 1964 production is considerably higher: 525,000 tons (Indices of Agricultural Production..., op. cit., p. 26).

^{4/} FAS Report MX 9008, op. cit.

^{5/} Myren, op. cit.

^{6/} Firch and Young, op. cit., p. 30; William J. Higgins, Mexico's Production of Horticultural Products for Export, U. S. Department of Agriculture, Foreign Agricultural Service, FAS M-199, June 1968, pp. 3-4.

IV. SOCIAL, POLITICAL & ECONOMIC CONSIDERATIONS

The average wheat and corn producers in Mexico are quite different. The wheat grower tends to run a large commercial operation: as Myren puts it, "he grows his crop under irrigation and sells it, either directly or indirectly, to the miller for processing". By contrast the "vast majority of farmers who grow corn do so first of all to provide food for the family ... and secondly to produce a marketable surplus." ^{1/}

Where improved varieties of both have been adopted, it has largely been by the larger growers in irrigated areas. Hicks reports that 90% of the increase in wheat production in northern Mexico was on private properties larger than 5 hectares. ^{2/} This is probably less true of corn. In either case, the rate of adoption by small growers in non-irrigated districts has undoubtedly been low. Hence the poor growers have largely been bypassed.

There has been some economic reason for this pattern of development. Still, if social considerations had been given greater weight, more of an effort could have been made to expand irrigation in areas with a greater population density. Furthermore, more could have been done to improve extension and the distribution of new seeds and other inputs among small growers.

^{1/} Myren, op. cit.

^{2/} Hicks, op. cit., p. 396. The ejido holdings are not private property.

The overall situation as of the mid 1960's was well summarized by Freebairn:

Public investments largely in irrigation, agricultural credit, technical developments and their implementation, and the provision of production inputs, have been singularly concentrated in the hands of a limited number of farmers and into a fairly restricted geographic area. Limited resources have been concentrated. In a very real sense, public policy has been to create a new and commercial agriculture almost from virgin regions; attempts to modernize and reform established and traditional agriculture have been almost nonexistent.^{3/}

Steps are now being undertaken to improve dry land varieties and cultural practices which will help rectify the situation. But even in these cases, a more general problem may be encountered: "Survival in subsistence production areas in central Mexico depended on the success or failure of the corn crop and this appears to have created extreme conservatism in production practices."^{4/}

In summary, it might be said that the Mexican program has been quite successful in the sense that overall production has increased to the point where massive imports are no longer need; indeed, the nation is faced with the problem of finding export markets for surplus production. But on the other hand, large segments of the rural population have not benefited from the fruits of technological progress. Work has been initiated to help rectify this situation, but it may be sometime before it begins to pay off for the small farmer. And in any case, the overall market for the small farmers product will not be bolstered by the already heavy overall supplies emanating from the large producing areas.

^{3/} Freebairn, op. cit., p. 37.

^{4/} Hicks, op. cit., p. 401.

In consequence, there is little from the Mexican example, other than research organization, that would serve as a positive model for the less developed nations. But the Mexican experience does point out the economic and social problems that can be involved if the focus is limited to inputs and research for irrigated crops. And it also points out the price policy problems that may be faced when self-sufficiency is passed. What is past in Mexico could well be prologue for other developing nations.

V. APPENDIX

Grain Quality*

The original Mexican semi-dwarf wheat varieties Penjamo 62 and Pitic, had definite defects from an industrial standpoint, despite their high yield:

- Pitic had low grain test weight and weak gluten;
- Penjamo 62, although possessing grain of high test weight and good milling characteristics had weak gluten and poor bread making characteristics.

A milling and baking laboratory was installed in 1958. By 1964 a technique had been worked out for early generation screening. Since this method has been evolved and used, the quality of the wheat varieties emerging from the Mexican breeding program has improved markedly.

* Extracted from CIMMYT Report, 1967-68, p. 78.

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